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RETENTION OF SKILL AFTER LAPSE OF PRACTICE: SIMULTANEOUS READING AND WRITING

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In the twenty-sixth volume of this JOURNAL we reported an experiment upon Automatic Writing, the outcome of which was of interest chiefly because of its bearing upon the possibility of maintaining two simultaneous activities, in this instance reading and writing. As it required considerable effort and practice in order to acquire such measure of skill as we did attain in manipulating the double process, it seemed to us when opportunity offered worth while testing the retention of capacity after a long interval of non-practice. Our last experimental session in any series of the above investigation took place May 14, 1914; our first in 1916 on July 28. In the 1916 investigation the conditions of 1913-14 were duplicated exactly. Both subjects (*D* and *A*) were, however, in better physical condition in 1916 than in 1914; *D* decidedly so. The series of 1916 were carried on solely for purpose of comparison of expertness after the long lapse in practice and were confined to reproduction of only two of the situations dealt with previously, namely writing a memorized verse, (I) while maintaining silent reading, and (II) while reading aloud. In every case the writing was screened from the writer. In 1914, we had found that after much practice we succeeded in bringing the simultaneous processes somewhat closely to the normal speed-limits but the situation was so complicated and required such tension of effort, that we would not have been surprised to find that our hard-won virtuosity had wholly evaporated. This did not prove to be the case.

For directly testing retention of capacity our records, however, leave much to be desired. Our purpose in 1913-1914 being primarily to study the conditions under which automatic writing appears, we varied certain factors in a way that introduces some range of error in the determination of practice effects. For example, the length of the writing interval was governed, in part, by the natural divisions of the story we chanced to be reading. This allowed us to test the effect upon

'distraction of attention' of an increased interest in the story as it approached a climax. In part, we deliberately shortened or lengthened the writing period in order to note the effect of warming-up and of fatigue upon automatic writing. For our present purpose a constant time-interval or a constant number of times of writing the memorized verse between pauses would have been more satisfactory. However, the records make possible some very interesting comparisons.

Before reporting the facts with respect to the double process we shall make a statement concerning the normal spurted speed records of 1913-1914 and 1916, for both reading and writing. The writing records are in terms of the time in seconds required for writing the test verse; the reading-rate in terms of the number of words read per second. In the interval between the practice at speeding, both writing and reading had, of course, continued as normal activities. *A*, as a university graduate student, has presumably practised spurted writing in connection with the taking of lecture notes; *D* had, on the contrary, become interested in a printing movement in writing which might be expected to cause some retardation in speed. So far as reading was concerned, a retardation in *A*'s rate might reasonably have been anticipated from the fact that he had done in the interval considerable critical reading of philosophical prose. *D*, on the other hand, had made some conscious effort to increase her reading rate.

In getting our normal writing-speed for the given verse, perfectly memorized, we had found in 1913-1914 a progressive increase in speed with, as we had thought, an approach to a physical limit in the case of *A*, with whom the investigation was carried out at much greater length than with *D*. The normals for the writing-rate had been obtained both with and without the use of a screen, the records with the screen being consistently more rapid than those without it. *A*'s gain on his initial record, 1913-1914, without the screen, was 5.2 seconds or 12.3 per cent of the initial record. We did not begin taking the normal without the screen until the experiment had run some time so that our records in this respect are inadequate. Nor have we a sufficient number of normals with *D* to make a comparison of much value.

It is, however, possible to compare in *A*'s case the average, the fastest, and the slowest records of the last seven trials in 1913-1914 with the average, the fastest, and the slowest of the first seven trials of 1916. These results are presented in Table I. The last speed records of 1913-1914 were taken for *A* in February, 1914; for *D*, in November, 1913.

TABLE I
NORMAL SPEED RECORDS. WRITING TEST VERSE

Reagent	With Screen					Without Screen										
	1914					1916					1916					
	Av. last 7 trials	M.V.	Fastest	Slowest	Av., last 7 trials	M.V.	Fastest	Slowest	Av., last 7 trials	M.V.	Fastest	Slowest				
A	35.7	1.2	33.0	38.0	33.3	1.6	29.8	36.0	36.9	1.1	33.5	40.2	37.5	1.6	34.0	42.0
D					*57.0	2.48	52.5	60.0	†58.94	2.58	54.4	63.2	57.3	3.96	52.0	63.0

* Average of four trials only. † Average of five trials only.

In the case of *A* the average of the first seven trials with the screen is in July 1916, 2.4 seconds or 6.7 per cent more rapid than the last seven in 1914. The fastest speed record for 1916 is 3.2 seconds faster than the speediest for 1914. Without the screen the average for the last seven 1914 is 0.6 seconds faster than the average for 1916, less, however, than the M. V. In both instances, there is a slight increase in the M. V. for 1916.

We interpret this to mean that the effort at increased speeding was checked by the visual perception of the result when the screen was not used; and that, in 1914, *A* had practically reached the limit of writing rapidly consistent with such measure of visual conscience (for penmanship!) as he possessed, advancing from over three to more than four letters per second.

A comparison of the illegibility of the records confirms this conclusion. All of *A*'s spurted speed records are highly illegible but those with the screen more so than those without. A comparison of the first record with the screen, 1916, shows only one second's difference from the last of 1914, a loss less than the mean variation on the last series. The practice effect continues from the first trial on, when the writing is screened from view, although spurting is carried no further in 1916 when writing is visible.

For *D*, who wrote the verse for only one series of experiments in 1913-1914, there are only five records without the screen; the average, 58.9, shows slightly greater rapidity than the average for five in 1916; the M. V. in 1916 is, higher. There are no adequate records for a comparison of the normals without the screen.

We may next consider the normal records for rate of reading in the different years, Table II. These records afford less opportunity for exact comparison than the writing records since they are, in part, dependent upon the text read, upon the stylistic qualities of the author, and upon the variation in interest in the story from point to point. There is perhaps some evidence of a slight increase in *D*'s silent reading-rate, 1916, and a slight decrease in that of *A*. Reasons for this have already been suggested. *A*'s rate of reading aloud would, however, seem slightly increased. The rate of reading aloud is greatly dependent upon degree of effort. In 1914, *A* had learned a means of controlling the voice, etc., that had progressively increased his rate but at a sacrifice of enunciation. It was the impression of the experimenter that in 1916 there was, very evidently, an increased distinctness of enunciation

TABLE II
NORMAL SPEED RECORDS. READING WORDS PER SECOND

Reagent	Silent			Aloud		
	1914			1916		
	First trial, Oct.	Av., last 5 trials, Nov.	Range through whole series	Av., 4-6 trials	Range	Av., 7 trials
A.....	8.9	10.4	8.6-12.5	8.2	7.3-9.0	4.24
D.....	7.4	6.7	5.4-7.6	8.0	6.5-9.2	3.26-5.67
				4.03	4.01-5.76	(one trial) 3.98

TABLE III
SPEED RECORDS. WRITING TEST-VERSE. DISTRACTION

	Reagent	1913-1914						1916					1914-1916	
		Av., first lap	Av., last lap	Whole No. of trials	Absolute gain	Relative gain, per cent		Av., first lap	Av., last lap	Whole No. of trials	Absolute gain	Relative gain, per cent	Absolute loss, 1914-1916	Relative loss, 1914-1916
Writing Distraction I	A	57.58 M.V. 2.16	42.2 M.V. 1.07	116	15.38	26.0		44.1 M.V. 2.05	36.7 M.V. 2.5	35	7.4	16.8	1.9	4.5
	D	89.38 M.V. 13.8	64.27 M.V. 1.48	232	25.11	28.1		71.5 M.V. 5.4	59.7 M.V. 1.9	37	11.8	16.5	7.23	11.2
Writing Distraction II	A	71.21 M.V. 15.3	37.96 M.V. 3.01	168	33.25	46.7		62 M.V. 3	37.6 M.V. 1.7	43	24.4	39.4	24.04	63.3
	A	7.7	9.3	10	1.6	20.8		6.1	8.01	5	1.91	31.3	3.2	34.4
Silent Reading	D	2.4	4.2	11	1.8	75.0		?	4.86	4	?	?	?	?
	A	2.31	3.62	23	1.31	56.7		2.5	3.52	18	1.02	40.7	1.12	30.9

in conjunction with rapidity, a point of some interest and possibly dependent upon general developmental factors.

Let us turn now to the records when reading and writing are run together, Table III. In our first series of experiments writing was maintained in connection with silent reading (Distraction I). In this instance we are able to make some interesting comparisons, first, between the last lap in 1913-1914 written in pencil, and the first in 1916. The last series of all in 1913 is not taken into consideration inasmuch as this record, contrary to the usual custom, was done in ink. The elimination of this series introduces, however, no error since the records of this day are poorer than those of the preceding session, except in two instances for *D*.

A's first lap (average of 11 trials) in 1916 shows on the face of it a loss of only 1.9 seconds from the last lap of Nov. 1913 (10 trials), a variation which is only slightly more than the mean variation of the last lap of 1913. It must, however, be remembered that *A*'s practice in writing the given verse under distraction was continued with reading aloud after the distraction of silent reading was dropped, so that it would be more significant to compare his final record under distraction (II) for 1914 with the first for 1916. This final record was 37.96 and using this as a basis for comparison we find a loss of 6.14 seconds or 16.1 per cent. As reading aloud was decidedly more distracting for *A* than was silent reading, it seems probable that this loss of more than 6 seconds lies within the actual loss from lapse of practice. *D*'s loss on the final record was 7.23 or 11.2 per cent. Both *A*'s and *D*'s records show in 1916 an increase in the variation of the individual speed records from the average.

Reference to the records shows that by the third day's practice (1916), with silent reading as a distraction, both *A* and *D* had passed beyond the average record of the last lap for 1913-1914 and had established a new speed record. The question arises whether there has been an actual gain in the interval of non-practice in the speed with which learning went on. Our general impression from the introspective ease with which the process was maintained was that this was true. Later, we shall need to reconsider this conclusion.

The experiment involving writing while reading aloud (Distraction II) was carried out in 1914 with *A* alone. Here the loss from the final lap of 1914 to the initial one of 1916 was 24 sec. or 63 per cent. These records are not subject to the error of Distraction I. A comparison of the two records

shows in any case a decidedly greater loss for the situation which for *A* was the more complicated one.

Turning now to the reading records we find that *A* has lost considerably in rate of reading. It is, however, impossible to determine how much this is due to loss of capacity for carrying on the double process since there has also been a decrease in the normal rate of silent reading. It is probably better to confine ourselves to the writing records.

The question raised above then becomes paramount. Since the learning process is one in which a practice effect is continuous, does the rate at which the practice effect goes on increase, decrease, or remain constant after the long interval of rest? There is, possibly, some difference in the case of the two subjects.

In 1916, *D* wrote the verse thirty-seven times under distraction of silent reading. Her initial record was 83 seconds; her final record, 56 seconds; a gain of 27 seconds or 32.5 per cent in the thirty-seven trials. If we take the last thirty-seven records of 1913-1914 (ink records omitted) we find a drop from 70 seconds to 62.4 seconds or a gain of 7.6 seconds, that is, a gain of 10.8 per cent in 37 trials. The rate at which practice went on would seem then to be slightly increased in 1916. Recovery of skill in 1916 took place rapidly so that by the fifth trial *D* is within 0.8 seconds of her final average for 1913. From that point on until the close there was a gain of 13.8 per cent.

If we compare the averages of the laps instead of individual records, we find a confirmation of our conclusion as to an increased rate of improvement. On Nov. 11, 1913, *D*'s average for sixteen trials was 71.52; in July, 1916, the average of thirteen trials (first lap) was 71.50; practically the same. But in the two following laps of approximately the same number of trials there was a fall to 64.27 in 1913 or a gain of 10.1 per cent; in 1916, to 59.7, a gain of 16.5 per cent. There is, then a slight increase in the rate at which practice went on for *D*. The *M. V.* is, however, slightly higher in 1916.

A's record, Distraction I, is subject to less obvious interpretation because of the complication of the practice effect with that of Distraction II. He did not, however, approximate his average final record on verse-rapidity with Distraction I, 1913, until his eleventh trial in 1916; nor his final average for verse-rapidity, 1914 (if we take both forms of distraction), until his fifteenth trial. From that point on his relative rate of increase, 1916, was 12.7 per cent, very similar

to *D*'s rate of increase. In 1914, the last twenty trials show no constant increase so that we had concluded that *A* had reached his practice limit.

In 1916, *A* wrote the verse, while reading aloud, forty-three times. The initial record was 60 seconds; the final record, 34.2 seconds, a gain of 25.8 seconds or 43 per cent. If we take the last forty-three records of 1914 (ink records omitted) we find a drop from 49.3 to 36.9, or an increase in rapidity equivalent to 25.1 per cent. Approximation to the final *average* record of 1914 did not occur, until the thirty-ninth trial in 1916; and rapidity increased in the next five trials only 10.5 per cent. The practice effect manifests itself here in a very rapid re-learning. If we take the averages of the laps we find that on Feb. 19, 1914, (44 trials before the close) *A*'s average for six trials was 47.95. In July, 1916, the average of his first four trials was 62. In 1914, the record fell, in forty-four trials, to 37.96—a gain of ten seconds or 20.9 per cent. In 1916 there was a drop in forty-three trials, from 62 seconds to 37.6 seconds, or 39.3 per cent gain. But in large measure the process is one of re-learning.

Unfortunately we do not possess enough data to be able to draw conclusions as to the difference between *D*'s record with distraction I and *A*'s with distraction II. We expect, however, the greater loss to occur for the more complicated process. Possibly, too, the fact that *A* in 1914 approached more nearly the limit of his capacity for carrying the double process than did *D* accounts for some of the difference. Possibly *D*'s improved condition in 1916 is a factor in the case.

Table IV summarizes other data that bear on a comparison of the records of the two reagents. First of all, we note that the relative loss on the normal in the first four trials for 1913 was with Distraction I much higher for *D* than for *A*; in 1916, the relative loss has become practically the same for both.

In this connection we tested *D*'s ability to maintain writing while reading aloud. In 1914, *D* did not try this experiment. Our notes show that in the series in which mental arithmetic was used as a means of distraction, she was unable to carry the double process because of difficulty in handling mental arithmetic. No record occurs concerning writing while reading aloud. If our memory is correct, however, we found the series so long with *A* (twenty-three days of from one hour to two hours' practice each were required to approximate the normal average) that we did not have time to use both subjects. Judging from the ease with which *D* handled the

TABLE IV
SPEED RECORDS. WRITING TEST-VERSE AND NEW VERSE

Reagent	Year	First normal	Average, first four trials	Absolute loss	Relative loss, per cent	First normal	Average, first four trials	Absolute loss	Relative loss, per cent
		Distraction I				Distraction II			
		"Thirty days hath Sept."				"Thirty days hath Sept."			
A.....	1913-14	39	56.3	17.3	44.4	39	82.8	43.8	112.3
A.....	1916	34	44.6	10.6	31.2	36	62.0	26.0	72.2
D.....	1913	59	97.5	38.5	65.3	Not tried.			
D.....	1916	60	79.5	19.5	32.5	52.5	79.3	26.8	51.0
		"Mary has a little lamb."				"Mary has a little lamb."			
A.....	1916	23	26.6	3.6	15.7	23.5	43.5	20.0	85.1
D.....	1916	32	34.0	2.0	6.2	31	50.5	19.0	61.3

given verses in 1916, she would have found this test relatively easier than distraction I. In our notes on taking dictation while reading aloud we noted in 1914 that, relatively, *D* read aloud much more rapidly than she read silently, a fact true also for her normal reading rate.

With Distraction II, *D*'s first attempt in 1916 shows less loss on her normal than does *A*'s first trial in 1916 after 168 trials in 1914. Her relative loss is less than for the average of her first four trials with Distraction I. She had a feeling of having carried over to the new situation the skill acquired in Distraction I; if so, she transferred this capacity very much more effectively than *A* gave any evidence of doing. .

In this particular experiment we have, on the one hand, a motor factor involving the unwinding of a series of mechanical movements corresponding to the verse words. On the other hand, we have the maintenance of a double set (attentional). The difference between *A*'s and *D*'s records can be understood if *A*'s acquirement of skill is primarily motor, an unwinding of specific movements, and *D*'s due to a general set of attention, which might more easily function in a modified situation.

In order to obtain data for determining to what degree success in writing the given verse was due to a special motor habit and how far dependent upon general habits of attention we shifted finally to another verse and wrote it while maintaining (I) silent reading and (II) reading aloud. Table IV presents the results.

In *D*'s case, the second verse with silent reading as the distracting process, goes easily from the first. Apparently the whole effect of practise is carried over. *D* reported, however, that the second verse was very much easier to handle than the first, because of its employment of simpler words and a more regular rhythm.

Likewise in *A*'s case the writing of the second verse during silent reading goes easily from the first, indicating that a considerable practice effect is carried over to the new verse. In *A*'s case, however, the relative loss, while only a third of that for the original loss on the test verse in 1913-14, is still twice as great as that of *D* on the new verse in 1916 (which was one-tenth of that on the test verse in 1913). The relative loss of *A* on the new verse is one-half that on the repetition of the test verse in 1916, while that of *D* on the new verse is one-fifth of her loss on the repetition of the test verse in 1916. This confirms the existence of a difference in *A*'s and *D*'s type of reaction to the general situation.

With distraction II, *D*'s relative loss on the new verse is somewhat greater than that on the test-verse, but the latter had the benefit of the practice effect of writing under distraction I. *A*'s record shows some evidence of transfer effect, if we go back to the initial record in 1913; but there is evidence of loss if we consider only the final record. In any case, *D* handled the situation more easily than *A*, in spite of his long practice. We conclude that the two subjects give evidence of a significant difference in reaction.

Introspectively *A* reported that in the first fourteen trials 1916 (Distraction I) he went through the whole course of development of 1913-1914. The writing-cue became progressively bigger and bigger. In some respects it seemed to *A* that writing was more automatic than it had been two years before; there was a tendency more frequently to lose his place so that he was bothered by the feeling of not knowing where he was at in the verse.

Lapses were exceedingly frequent in *A*'s 1916 records. In some cases these lapses are simply the cutting of strokes and the dropping out of letters so evidently the result of spurting. The limit toward which *A* was obviously moving was a mere scratching of the pencil, wholly indecipherable, synchronous with the feeling of line-meaning. Before this point was reached in 1916 it was possible to observe some of the old lapses reappearing. Others wholly new put in an appearance, for instance, a confusion in the order of lines so that all are present but in a curiously mixed order. Another change in the appearance of the writing was a shift in the length of the verse lines. *A* broke away from the conventional arrangement in such a fashion as to keep the length of the lines uniform. The intention to spurt operated and induced new methods of increasing speed. These shifts in reaction indicate a relatively greater flexibility in handling the material in 1916 than at the close of 1914 and explain the possibility of *A*'s passing beyond the record of 1914 in which practice had apparently reached its limit. The rest-interval, with its breakup of certain mechanisms, gave freedom for new adaptations. Book expresses it from the other side when he states that the rest-interval operates in causing the dropping out of bad habits.

As was true in 1913-1914, *D*'s lapses in 1916 are in a large measure conspicuous by their absence. Where they appear they are the old lapses of 1913, namely a doubling of the initial stroke on the "y" and "n" and a repeating of "i," with the old curious loss of all motor report for this tiny stroke.

Summary. There is considerable retention of capacity to maintain two processes (reading and writing) after lapse of practice for more than two years, with a rapid re-learning and approximation of one's last record. Subject *D* showed a quicker recovery than Subject *A*. The records of *A* also indicate a much greater loss of capacity for handling the situation that he found the more difficult of the two utilized.

Transfer of the practice effect appeared more evidently for subject *D* than for subject *A*. Since the situation involves both motor and attentional factors, it suggests itself as an excellent one to use in a specific investigation on generalized habits.